Effect of Axle Load Measurement Errors on Pavement Performance and Design Reliability

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In traffic characterization, axle load spectra (ALS) are One of the must critical inputs in the new j\1echallistic-Elllpirical Pavement Design Guide (~'lEPDG-).ALS have a !'igllificant impact on the predicted pavement performance ..4t the design stage, it is typically assumed that Al.S as measured by wclgh-ln-motton (WIM) systems have adequate data quality and accuracy. In Iact, the quality ofWIM·based data has inherent uncertainties because of inaccuracy and systematic bias. 'Vhile WL"f data accuracy depends 011 the sensor technology, calibration errors and clrift over umc may Introduce a systematic bias. Several studies have Investigated tbe impact of traffic dahl collection technologies. data coverage, at-curacy. and calibration errol'S on pavement loading and performance prediction. However, these studies were limired to a few distress measures and did not address design reliability aspects .I5 COn-sidcred in the Mi!:PDG.This smdytnvesugated thc Impact of probeble \VI1". errors on the ALS and quantified the eO'eets of these errors on the performance efboth flexible and rigid pavements. Furthermore, the impact of uncertainties in ALS on design reliahilities is discussed in this paper. Although most findings reinforce existing concepts, the study prnvides a systemauc overview of'\Vl\1 data accuracy and callbratton requirements, and uie ell'ect of associated uncertainties in the pavement design process. The results show that cracking in both flexible and rigid pavements is the distress most affected by ALS vartatious. while rutting In Hcxiblc pavements is moderately affected.

Traffic characterization and related inputs playa vital role in the analysis and design of pavements in the new *Mechanistic-Empirical Pavement Design Guide* (MEPDG). The main reason for their significance is the associated high degree or uncertainly. In addition, the effects of traffic-related inputs are more pronounced because the MEPDG directly uses traffic COUntS and axle load spectra (ALS) to determine pavement damage. Subsequently. the accumulated pavement damage is related to predicted pavement performance through transfer functions. The traffic data required by the MEPDG include *(a)* traffic volume adjustment factors (hourly adjustmenr factor, monthly adjustment factor, vehicle class distribution, and traffic growth factor); *(b)* AI.S for various axle configurations: and *(c)* general traffic inputs (number of axles per truck, axle configuration. and wheelbase. etc.) *(1-3)*. Among the three traffic-related inputs, ALS require extensive efforts in data collection, and several sensitivity studies have shown that ALS significantly affect pavement performance (4-7). In practice. traffic data collection is carried om by a combination of sensor technologies that include weigh-in-motion (\VIM) systems. automatic vehicle classifiers (Ayes), and automated traffic recorders. Each of these technologies has inherent uncertainty in the measurements. For example, two approaches are commonly adopted 10 collect axle loads: static and WIM scales. While SIalic weighing has beuer accuracy, a number of practical issues and inefficiencies accompany this practice. The 1l10St important limitation of static weighing is the amount of axle load data that can be collected. On the other hand, since pavement design and analysis require a large and representative amount of traffic data. state-of ..the-art WJI\-1lechnology is popular because of its ability 10 collect traffic data continuously, albeit with less accuracy. In addition. WIM system errors introduced by sensor technology, environmental effects, pavement condition, and other factors need to be considered to address concerns over measurement accuracy (8).

Because of extensive traffic data requirements inthe MEPDG, data from sites having similar traffic loading and classification attributes are used to complement data collected at a particular pavement design location. To compensate the levels (site-specific, regional. and national) or traffic data collection, three traffic input levels arc specified in the NlEPDG. These traffic input levels have associated uncertainty in performance prediction. An fHWA study highlighted the need for optimum traffic data collection for specific pavement design applications (9). Traffic data collection strategies were evaluated by considering a combination of technologies and coverage (duration of data collection). The results of this sensitivity study showed that discontinuous traffic data collection scenarios involving site-specific Wfi\.1data had significantly more potential for error when compared with continuous coverage of site-specific A VC data *(10)*. Further, the error in performance prediction can range from 10% 10 27% depending on the reliability ofusing regional axle load data instead of site-specific data. When the national axle load data are used for a site. the life prediction errors may range from 30% 1076% (9). These findings demonstrate Ihat variations in ALS can cause significant changes in a particular pavement design. Axle load underestimation is considered the most critical problem as it leads to the overestimation of pavement life and thus C,UI produce pavement structures with insufficient structural capacity. II should be noted that all the uncertainty associated with the traffic data is assumed to be contributed by a combination of traffic data collection technology and its coverage.

It is typically assumed that ALS are measured accurately and extensively for most analysis and design scenarios. However, measurement

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